

Title: Assessing the contributions of metals in environmental media to exposure biomarkers in a region of ferroalloy industry

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Supplemental Table 1. Analytical limits of detection for the analysis of metals in environmental and biological samples

	Manganese	Lead	Chromium	Copper
Environmental Media				
Air (ng/m ³)	3.5	3.5	3.5	3.5
Soil (ppm)	37.7	2.13	-	7.66
Dust (in leachate; µg/mL) ^a	0.0013	0.0367	0.0023	0.0026

Biomarkers (ng/mL, as analyzed)				
Blood	0.018	0.015	0.002	0.061
Hair	0.006	0.002	0.003	0.066
Nails	0.033	0.017	0.012	0.044
Saliva	0.011	0.004	0.009	0.032
Urine	0.004	0.003	0.003	0.011

a - From Lucas et al. 2015.

Supplemental Table 2. Spearman correlation coefficients for lead, chromium, and copper in environmental media and biomarkers

	Air Pb	Soil Pb	Indoor dust Pb	Outdoor dust Pb	Blood Pb	Hair Pb	Nail Pb	Saliva Pb
Soil Pb	-0.16 *							

Indoor dust Pb	0.09	0.10						
Outdoor dust Pb	0.17 *	0.10	0.24 **					
Blood Pb	0.05	0.14 *	0.04	-0.04				
Hair Pb	0.03	0.06	-0.09	0.01	0.22 **			
Nail Pb	-0.04	0.00	0.10	0.01	0.13 *	0.06		
Saliva Pb	0.01	-0.20 *	-0.13 *	0.01	0.10 *	0.11 *	-0.12 *	
Urine Pb	-0.15 *	0.00	-0.01	0.10	0.26 **	-0.06	0.11 *	0.06

	Air Cr	Indoor dust Cr	Outdoor dust Cr	Blood Cr	Hair Cr	Nail Cr	Saliva Cr
Indoor dust Cr	0.08						
Outdoor dust Cr	0.09	0.09					
Blood Cr	-0.07	-0.04	0.11 *				
Hair Cr	0.01	0.07	0.06	-0.05			
Nail Cr	-0.07	0.05	0.09	0.21 **	0.18 **		
Saliva Cr	0.13 *	0.01	-0.01	-0.23 **	0.03	-0.01	
Urine Cr	0.13 *	0.06	-0.03	-0.07	-0.09	-0.16 *	0.21 **

	Air Cu	Soil Cu	Indoor dust Cu	Outdoor dust Cu	Blood Cu	Hair Cu	Nail Cu	Saliva Cu
Soil Cu	-0.03							
Indoor dust Cu	0.05	-0.06						
Outdoor dust Cu	0.06	0.00	0.11 *					
Blood Cu	0.04	-0.08	-0.23 **	-0.05				
Hair Cu	-0.01	-0.08	0.04	0.14 *	-0.19 *			
Nail Cu	-0.03	0.08	0.08	-0.02	-0.09	0.05		
Saliva Cu	-0.01	-0.04	-0.02	-0.08	-0.07	-0.20 **	0.08	
Urine Cu	-0.02	-0.06	0.06	0.00	-0.27 **	0.07	-0.06	0.14 *

*p < 0.10; **p < 0.05

Supplemental Table 3. Average weights^a for environmental media and estimated associations between weighted environmental exposure index and exposure biomarkers, from WQS regression^b: Sensitivity analysis with indoor and outdoor dust surface loadings ($\mu\text{g}/\text{m}^2$).

Biomarker	n	Average Weights			Weighted Environmental Exposure Index	
		Air	Soil	Indoor dust	Outdoor dust	Beta (95% CI)
Manganese						
Blood	242	0.14	0.00	0.78	0.08	0.00 (-0.04, 0.04)
Hair	235	0.52	0.45	0.01	0.02	0.15 (0.02, 0.28)**
Nails	210	0.04	0.65	0.21	0.10	0.41 (0.21, 0.60)**
Saliva	243	0.68	0.3	0.00	0.01	0.29 (0.11, 0.48)**
Urine	204	0.15	0.66	0.17	0.02	0.16 (-0.02, 0.34)*
Lead						
Blood	135	0.11	0.36	0.27	0.26	0.14 (0.01, 0.28)**
Hair	132	0.21	0.17	0.49	0.14	0.04 (-0.28, 0.37)
Nails	111	0.00	0.29	0.70	0.01	0.30 (-0.03, 0.63)*
Saliva	133	0.18	0.02	0.42	0.39	0.02 (-0.33, 0.37)
Urine	111	0.03	0.40	0.02	0.56	0.11 (-0.01, 0.23)*
Chromium						
Blood	256	0.04	-	0.06	0.90	0.06 (-0.02, 0.14)
Hair	249	0.73	-	0.24	0.03	0.01 (-0.09, 0.11)
Nails	207	0.32	-	0.51	0.17	0.07 (-0.10, 0.24)
Saliva	256	0.89	-	0.11	0.00	0.08 (-0.06, 0.21)
Urine	218	0.77	-	0.23	0.00	0.00 (-0.09, 0.09)
Copper						
Blood	101	0.52	0.30	0.05	0.13	0.02 (-0.03, 0.06)
Hair	134	0.03	0.08	0.44	0.45	0.04 (-0.10, 0.17)
Nails	116	0.18	0.63	0.18	0.01	0.08 (-0.04, 0.21)
Saliva	135	0.24	0.27	0.37	0.11	-0.04 (-0.36, 0.27)
Urine	111	0.18	0.56	0.26	0.00	0.02 (-0.12, 0.16)

a – Weights were generated across 100 bootstrap samples.

b – All models adjusted for child's sex and age. Betas represent percent change in biomarker per 25% increase in weighted environmental exposure index. *p < 0.10; **p < 0.05

Supplemental Table 4. Average weights^a for environmental media and estimated associations between weighted environmental exposure index and exposure biomarkers, from WQS regression^b: Sensitivity analysis excluding children from subregion with current ferroalloy activity (Bagnolo Mella).

Biomarker	n	Average Weights				Weighted Environmental Exposure Index Beta (95% CI)
		Air	Soil	Indoor dust	Outdoor dust	
Manganese						
Blood	121	0.43	0.00	0.57	0.00	0.00 (-0.06, 0.07)
Hair	118	0.28	0.18	0.49	0.05	0.15 (-0.04, 0.35)
Nails	111	0.03	0.53	0.08	0.37	0.63 (0.37, 0.89)**
Saliva	121	0.64	0.20	0.04	0.12	0.35 (0.08, 0.63)**
Urine	99	0.17	0.67	0.00	0.16	0.20 (-0.05, 0.44)
Lead						
Blood	72	0.01	0.06	0.47	0.46	0.31 (0.14, 0.48)**
Hair	71	0.15	0.33	0.25	0.27	0.16 (-0.32, 0.64)
Nails	62	0.01	0.13	0.44	0.42	0.14 (-0.31, 0.59)
Saliva	72	0.55	0.01	0.00	0.44	0.11 (-0.33, 0.54)
Urine	60	0.00	0.24	0.13	0.63	0.18 (0.02, 0.34)**
Chromium						
Blood	121	0.03	-	0.14	0.83	0.02 (-0.09, 0.13)
Hair	118	0.23	-	0.42	0.35	0.07 (-0.15, 0.29)
Nails	103	0.10	-	0.35	0.56	0.16 (-0.06, 0.38)
Saliva	121	0.60	-	0.17	0.24	0.16 (-0.12, 0.45)
Urine	99	0.28	-	0.55	0.18	0.05 (-0.14, 0.23)
Copper						
Blood	48	0.24	0.39	0.03	0.35	0.03 (-0.02, 0.09)
Hair	72	0.09	0.24	0.03	0.65	0.07 (-0.14, 0.27)
Nails	66	0.27	0.04	0.23	0.46	-0.06 (-0.20, 0.07)
Saliva	72	0.24	0.39	0.33	0.04	-0.26 (-0.81, 0.28)
Urine	60	0.34	0.13	0.20	0.33	-0.07 (-0.35, 0.21)

a – Weights were generated across 100 bootstrap samples.

b – All models adjusted for child's sex and age. Betas represent percent change in biomarker per 25% increase in weighted environmental exposure index. *p < 0.10; **p < 0.05

Supplemental Table 5. Average weights^a for environmental media and estimated associations between weighted environmental exposure index and exposure biomarkers, from WQS regression^b: Sensitivity analysis excluding children from subregion with no ferroalloy activity (Garda Lake).

Biomarker	n	Average Weights			Weighted Environmental Exposure Index	
		Air	Soil	Indoor dust	Outdoor dust	Beta (95% CI)
Manganese						
Blood	196	0.19	0.19	0.34	0.28	-0.02 (-0.08, 0.04)
Hair	190	0.40	0.37	0.20	0.03	0.18 (0.02, 0.34)**
Nails	165	0.05	0.67	0.27	0.00	0.24 (0.00, 0.47)**
Saliva	196	0.67	0.28	0.04	0.01	0.38 (0.17, 0.59)**
Urine	158	0.44	0.38	0.15	0.03	0.19 (-0.03, 0.42)*
Lead						
Blood	109	0.27	0.48	0.10	0.15	0.09 (-0.03, 0.20)
Hair	106	0.21	0.04	0.30	0.45	0.18 (-0.13, 0.49)
Nails	89	0.04	0.47	0.36	0.12	0.16 (-0.25, 0.57)
Saliva	106	0.47	0.00	0.07	0.46	0.08 (-0.24, 0.40)
Urine	84	0.28	0.33	0.15	0.25	0.06 (-0.14, 0.26)
Chromium						
Blood	210	0.13	-	0.02	0.85	0.09 (-0.01, 0.18)*
Hair	204	0.24	-	0.40	0.36	0.00 (-0.12, 0.12)
Nails	167	0.32	-	0.59	0.09	0.17 (-0.01, 0.35)*
Saliva	209	0.66	-	0.08	0.26	0.11 (-0.07, 0.28)
Urine	172	0.47	-	0.41	0.13	0.11 (-0.02, 0.24)*
Copper						

Blood	78	0.38	0.31	0.00	0.32	0.02 (-0.04, 0.07)
Hair	105	0.07	0.18	0.16	0.59	0.08 (-0.08, 0.24)
Nails	88	0.36	0.52	0.02	0.11	0.11 (-0.07, 0.29)
Saliva	105	0.59	0.25	0.16	0.00	-0.04 (-0.35, 0.27)
Urine	82	0.23	0.25	0.39	0.13	0.01 (-0.20, 0.22)

a – Weights were generated across 100 bootstrap samples.

b – All models adjusted for child's sex and age. Betas represent percent change in biomarker per 25% increase in weighted environmental exposure index. *p < 0.10; **p < 0.05

Supplemental Table 6. Average weights^a for manganese in environmental media and estimated associations between weighted environmental exposure index and exposure biomarkers, from WQS regression^b: Sensitivity analysis stratified by distance to nearest ferroalloy plant (\leq median distance of 3.2 kilometers vs. $>$ 3.2 kilometers).

Biomarker	n	Average Weights				Weighted Environmental Exposure Index Beta (95% CI)
		Air	Soil	Indoor dust	Outdoor dust	
Distance to nearest site \leq 3.2 kilometers						
Blood	160	0.15	0.15	0.31	0.39	0.01 (-0.06, 0.07)
Hair	157	0.33	0.48	0.17	0.02	0.11 (-0.07, 0.30)
Nails	133	0.05	0.62	0.32	0.01	0.22 (-0.05, 0.48)
Saliva	161	0.61	0.24	0.12	0.04	0.37 (0.12, 0.61)**
Urine	133	0.38	0.25	0.31	0.05	0.11 (-0.13, 0.36)
Distance to nearest site $>$ 3.2 kilometers						
Blood	88	0.32	0.04	0.48	0.16	0.03 (-0.05, 0.10)
Hair	84	0.38	0.19	0.42	0.01	0.10 (-0.11, 0.32)

Nails	83	0.11	0.46	0.03	0.39	0.66 (0.38, 0.94)**
Saliva	88	0.51	0.46	0.02	0.01	0.45 (0.11, 0.79)**
Urine	77	0.26	0.68	0.02	0.04	0.18 (-0.12, 0.48)

a – Weights were generated across 100 bootstrap samples.

b – All models adjusted for child's sex and age. Betas represent percent change in biomarker per 25% increase in weighted environmental exposure index. *p < 0.10; **p < 0.05